REPLACEMENT DRAWINGS

Attached hereto please find a replacement drawing sheet for FIGS. 1 and 2, wherein the label “prior art” is added to FIG. 1.

REMARKS/ARGUMENTS

Prior to entry of this amendment, claims 1-21 are currently pending in the subject application. By the instant amendment, FIG. 1 is amended, claims 1-2 and 4-7 are amended and claims 3 and 9-21 are canceled without prejudice.

Applicants appreciate the Examiner's acknowledgement of applicants' claim for foreign priority and receipt of a certified copy of the priority document.

Applicants further appreciate the Examiner's acknowledgement of applicants' Information Disclosure Statement filed on January 24, 2005.

Claims 1-2 and 4-8 are presented to the Examiner for further prosecution on the merits.

A. Introduction

In the outstanding Office action, mailed July 22, 2005, the Examiner objected to FIG. 1, rejected claims 2, 3 and 5 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claims the subject matter which applicants regard as the invention, rejected claims 1-9 under 35 U.S.C. § 102(a) and/or (e) as being anticipated by U.S. Patent App. No. 2003/0017723 A1 to Hiramoto et al. ("the Hiramoto application"), rejected claims 1-9 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 6,108,177 to Gill ("the Gill reference") and rejected claims 1-9 under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,771,473 B2 to Hiramoto et al. ("the Hiramoto patent").

B. Objection to FIG. 1

In the outstanding Office action, the Examiner objected to FIG. 1 and required that it be labeled as "prior art." Applicants have provided herewith a replacement sheet for FIGS. 1 and 2, wherein FIG. 1 is labeled "prior art." Accordingly, applicants respectfully request that this objection be reconsidered and withdrawn.

C. Rejections under 35 U.S.C. § 112, Second Paragraph

In the outstanding Office action, the Examiner rejected claims 2, 3 and 5 under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claims the subject matter which applicants regard as the invention. In particular, the Examiner asserted that applicants' use of the terms "rich" in claim 2, "fixed layer" in claim 3 and "semi-ferromagnetic" in claim 5 is indefinite. Applicants respectfully traverse these rejections, each of which will be addressed in turn, below.

By the instant amendment, claim 2 has been amended to eliminate the term "a nitrogen rich layer" that formed the basis of the rejection of claim 2 under 35 U.S.C. §112, second paragraph. Applicants note that claim 2 now recites --the nitrogen-rich region--, in reference to --a nitrogen-rich region--, as presently recited in claim 1. Applicants respectfully submit that --a nitrogen-rich region-- is defined in claim 1 and that one of ordinary skill in the art would be reasonably apprised of the meaning of the term and the scope of the invention.

In particular, applicants note that claim 1 recites --the nitrogen-rich region containing more nitrogen than the pinned layer contains at a second surface of the pinned layer opposite to the interface, and the nitrogen-rich region containing more nitrogen than the tunnel barrier contains at a second surface of the tunnel barrier opposite to the interface--. Applicants respectfully submit that this language provides a sufficient standard for one of ordinary skill in the art to determine the meaning of the term --a nitrogen-rich region--. Accordingly, applicants respectfully request that the rejection of claim 2 under 35 U.S.C. §112, second paragraph, be reconsidered and withdrawn.

By the instant amendment, claim 3 has been canceled. Accordingly, applicants submit that this rejection is moot and respectfully requests that it be withdrawn. Applicants respectfully submit, however, that the original use of the term "fixed layer" in claim 3 is not inconsistent with

the use of that term by those of ordinary skill in the art and, accordingly, applicants reserve the right to reintroduce this term to the claims and respectfully submit that the cancellation of claim 3 is not because applicants doubt the patentability of claim 3 as originally filed.

In particular, applicants respectfully dispute the Examiner's assertion that the accepted meaning of "fixed layer" is only as an equivalent to the term "pinned layer" among those skilled in the art. For example, applicants note that Dr. Jon Slaughter of Freescale Semiconductor has publicly used the terms "fixed layer" and "pinned layer" to describe two different layers of a device, clearly demonstrating that the term "fixed layer" is not only used to mean "pinned layer" by those of ordinary skill in the art (see Appendix A). Therefore, applicants submit that the meaning of the term is not as fixed as the Examiner asserts and, accordingly, applicants respectfully submit that applicants' use of the term "fixed layer" to mean something other than "pinned layer" is not inconsistent with the use of the term among those skilled in the art. In view of the above, applicants submit that the meaning of the term "fixed layer" as originally recited in claim 3 is sufficiently defined by the phrase "includes a seed layer, a pinning layer, and a pinned layer" as to render it definite.

With regards to the Examiner's rejection of claim 5 under 35 U.S.C. §112, second paragraph, applicants respectfully traverse this rejection. In the outstanding Office action, the Examiner asserted that applicants' use of the term "semi-ferromagnetic" is contrary to its ordinary meaning. Applicants respectfully disagree, and submit that those of ordinary skill in the art would recognize the meaning of "semi-ferromagnetic." Accordingly, applicants submit that this term is not indefinite.

In particular, applicants note that claim 5 recites "the pinning layer is a semi-ferromagnetic layer formed of one selected from the group consisting of FeMn and IrMn." Thus, claim 5

provides a context for the use of the term "semi-ferromagnetic." Further, the Examiner has provided no evidence that applicants' use of the term "semi-ferromagnetic" is contrary to its ordinary meaning and not recognized in the art. Indeed, applicants respectfully submit that the term "semi-ferromagnetic" is an internationally recognized term among those of ordinary skill in the art. See, e.g., the attached recent publication produced by the National Institute of Materials Science (Japan), which uses the term "semi-ferromagnetic" in discussing magnetoelectronic materials research (Appendix B). Further, the term is also used in this context in, e.g., U.S. Patent No. 6,184,680. Therefore, applicants respectfully submit that there was no intention to redefine the term "semi-ferromagnetic." Accordingly, applicants respectfully request that this rejection be reconsidered and withdrawn.

D. Rejection Over the Hiramoto Application

In the outstanding Office action, the Examiner rejected claims 1-9 under 35 U.S.C. § 102(a) and/or (e) as being anticipated by the Hiramoto application. By the instant amendment, claim 1 has been amended to more particularly recite aspects of the present invention. No new matter is added and support for the instant amendment can be found in, for example, paragraph [0043] of the application as originally filed. Applicants respectfully submit that the Hiramoto application fails to disclose, or even suggest, each and every element of claim 1.

Claim 1, as currently amended, recites, in part:

> wherein a first surface of the tunnel barrier is adjacent to a first surface of the pinned layer, and
>
> a nitrogen-rich region exists at an interface of the first surface of the pinned layer and the first surface of the tunnel barrier, the nitrogen-rich region containing more nitrogen than the pinned layer contains at a second surface of the pinned layer opposite to the interface, and the nitrogen-rich region containing more nitrogen than the tunnel barrier contains at a second surface of the tunnel barrier opposite to the interface.

In the outstanding Office action, the Examiner asserted that the Hiramoto application discloses a "buffer layer formed of a metallic nitride interposed between the fixed [layer] and the tunnel barrier," referring to paragraphs [0158]-[0169], i.e., Example 4, of the Hiramoto application. *Office action of July 22, 2005, at paragraph 6, pages 5-6.* Example 4 discloses, at most, a silicon substrate having a SiO_2 film formed thereon; a first magnetic layer, e.g., FeSiAl or the materials recited in paragraph [0168], formed on the silicon substrate; a tunnel layer (high-resistivity layer) formed by oxidizing the surface of the first magnetic layer (the first magnetic layer also may be nitrided after forming the FeSiAl layer); and, finally, a second magnetic layer, e.g., NiFe, formed thereon. Thus, the Hiramoto application discloses, at most, a uniform nitrogen-containing tunnel layer. However, the Hiramoto application fails to disclose or suggest each and every element of claim 1.

In particular, the Hiramoto application fails to disclose a nitrogen-rich region at an interface of the first surface of the pinned layer and the first surface tunnel barrier and containing more nitrogen than the tunnel barrier contains at a second surface of the tunnel barrier opposite to the interface, as presently recited in claim 1. Accordingly, applicants respectfully submit that the Hiramoto application fails to anticipate claim 1. Claims 2 and 4-8 depend, either directly or indirectly, from claim 1 and are believed to be allowable for at least the reasons set forth above. Therefore, applicants submit that claims 1-2 and 4-8 are allowable, and respectfully request that this rejection be reconsidered and withdrawn.

E. Rejection Over the Gill Reference

In the outstanding Office action, the Examiner rejected claims 1-9 under 35 U.S.C. § 102(b) as being anticipated by the Gill reference. By the instant amendment, claim 1 has been amended to

more particularly recite aspects of the present invention. Applicants respectfully submit that the Gill reference fails to disclose, or even suggest, each and every element of claim 1.

In the outstanding Office action, the Examiner asserted that the Gill reference discloses a fixed layer 305, a tunnel barrier 308 and a metallic nitride buffer layer 306 interposed between the fixed layer and the tunnel barrier. Office action of July 22, 2005, at paragraph 7, page 8. However, the Gill reference fails to disclose or suggest each and every element of claim 1.

Applicants note that the Gill reference discloses that layer 306 is a pinned layer and layer 308, formed on the pinned layer, is an aluminum oxide spacer layer. *The Gill reference, col. 5, lines 37-44.* The Gill reference also discloses that the pinned layer 306 is made from iron nitride (FeN). *The Gill reference, col. 5, lines 37-38.* However, the Gill reference fails to disclose a nitrogen-rich region at an interface of the first surface of the pinned layer and the first surface tunnel barrier and containing more nitrogen than the tunnel barrier contains at a second surface of the tunnel barrier opposite to the interface, as presently recited in claim 1. Accordingly, applicants respectfully submit that the Gill reference fails to anticipate claim 1. Claims 2 and 4-8 depend, either directly or indirectly, from claim 1 and are believed to be allowable for at least the reasons set forth above. Therefore, applicants submit that claims 1-2 and 4-8 are allowable, and respectfully requests that this rejection be reconsidered and withdrawn.

F. Rejection Over the Hiramoto Patent

In the outstanding Office action, the Examiner rejected claims 1-9 under 35 U.S.C. § 102(e) as being anticipated by the Hiramoto patent. By the instant amendment, claim 1 has been amended to more particularly recite aspects of the present invention. Applicants respectfully submit that the Hiramoto patent fails to disclose, or even suggest, each and every element of claim 1.

In the outstanding Office action, the Examiner asserted that the Hiramoto patent discloses a fixed layer of Co/Ru/Co having a tunnel barrier layer (intermediate layer) stacked thereon, wherein a buffer layer formed of a metallic nitride (Fe(1), FeN) is interposed between the fixed layer and the tunnel layer. *Office action of July 22, 2005, at paragraph 8, page 10; applicants note that the example cited by the Examiner appears at col. 13, lines 48-53.* However, applicants respectfully submit that this assertion mischaracterizes the Hiramoto patent and the Hiramoto patent fails to disclose or suggest each and every element of claim 1.

In particular, applicants note that the Hiramoto patent fails to disclose *any* layer interposed between the fixed layer and the intermediate layer because the Hiramoto patent discloses the intermediate layer to be next to the fixed layer. See, e.g., the Hiramoto patent at col. 12, lines 50-54, wherein the disclosed film order is, in pertinent part, "laminated ferrimagnetic material/fixed magnetic material/intermediate layer." Thus, the Hiramoto patent discloses that the fixed magnetic material and the intermediate layer are next to each other, with nothing interposed therebetween. Accordingly, in the example cited by the Examiner, the fixed layer is properly characterized as including FeN, and FeN is not a buffer layer. Thus, the Hiramoto patent fails to disclose a nitrogen-rich region at an interface of the first surface of the pinned layer and the first surface of the tunnel barrier, the nitrogen-rich region containing more nitrogen than the pinned layer contains at a second surface of the pinned layer opposite to the interface, and the nitrogen-rich region containing more nitrogen than the tunnel barrier contains at a second surface of the tunnel barrier opposite to the interface, as presently recited in claim 1.

In view of the above, applicants respectfully submit that the Hiramoto patent fails to anticipate claim 1. Claims 2 and 4-8 depend, either directly or indirectly, from claim 1 and are believed to be allowable for at least the reasons set forth above. Therefore, applicants submit that

claims 1-2 and 4-8 are allowable, and respectfully request that this rejection be reconsidered and withdrawn.

G. Conclusion

Since the cited prior art relied on to reject the claims of the subject application fails to anticipate or render obvious the present invention, applicants respectfully submit that claims 1-2 and 4-8 are in condition for allowance, and a notice to that effect is respectfully requested.

If the Examiner believes that additional discussions or information might advance the prosecution of the instant application, the Examiner is invited to contact the undersigned at the telephone number listed below to expedite resolution of any outstanding issues.

In view of the foregoing amendments and remarks, reconsideration of this application is earnestly solicited, and an early and favorable further action upon all the claims is hereby requested.

Respectfully submitted,

LEE & MORSE, P.C.

October 24, 2005
Date:

Eugene M. Lee, Reg. No. 32,039

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PETITION and DEPOSIT ACCOUNT CHARGE AUTHORIZATION

This document and any concurrently filed papers are believed to be timely. Should any extension of the term be required, applicants hereby petition the Director for such extension and requests that any applicable petition fee be charged to Deposit Account No. 50-1645.

If fee payment is enclosed, this amount is believed to be correct. However, the Director is hereby authorized to charge any deficiency or credit any overpayment to Deposit Account No. 50-1645.

Any additional fee(s) necessary to effect the proper and timely filing of the accompanying-papers may also be charged to Deposit Account No. 50-1645.

APPENDIX A

Part 1: Symposium Program, Cornell CNS Nanotechnology Symposium, May 14, 2004
Part 2: Presentation delivered at the Symposium by Dr. Jon Slaughter, Freescale Semiconductor, pages 1 and 8.

CENTER FOR NANOSCALE SYSTEMS

1st Annual CNS Nanotechnology Symposium

Nanomagnetics - From Discovery to Systems

Ithaca, May 14, 2004

A one-day symposium organized by the Center for Nanoscale Systems, focused on scientific challenges and engineering opportunities in magnetic storage and memory technologies. Speakers from industry and academia have shared their experience and vision in this rapidly developing field.

8:15 - 8:30	Opening & Welcome Prof. Robert Buhrman, Director CNS Click here for the slides or video (Windows Media or QuickTime) of the presentation
8:30 - 9:10	Spin Transfer Stimulated Noise in Magnetic Recording Heads Prof. Bob White, Director Data Storage Systems Center, Carnegie Mellon Click here for the slides or video (Windows Media or QuickTime) of the presentation
9:10 - 9:50	Spin Transfer and Other Challenges in Data Storage Dr. Mark Covington, Research Staff Member, Seagate Click here for the slides or video (Windows Media or QuickTime) of the presentation
9:50 - 10:10	Morning break
10:10 - 10:50	MRAM Technology: Status and Future Challenges Dr. Jon Slaughter, Manager Magnetic Materials Research, Motorola Click here for the slides of the presentation
10:50 - 11:30	Spintronics Applications at NVE Dr. Jim Daughton, Founder and CTO of NVE Corporation Click here for the slides or video (Windows Media or QuickTime) of the presentation

11:30 - 1:00	Lunch & Poster Session
1:00 - 1:40	Spin Transfer Induced Dynamics in Magnetic Nanostructures Bill Rippard, Research Associate, NIST Click here for the slides or video (Windows Media or QuickTime) of the presentation
1:40 - 2:20	Circuit Considerations for Spin-Switched MRAM Devices John DeBrosse, MRAM Design Team Leader, IBM Microelectronics Click here for the slides or video (Windows Media or QuickTime) of the presentation
2:20 - 2:50	Spin Transfer Driven Magnetic Switching and Precession Prof. Dan Ralph, CNS Cornell Click here for the slides or video (Windows Media or QuickTime) of the presentation
2:50 - 3:00	Summary & Adjourn Prof. Robert Buhrman, Director CNS

This work is supported primarily by the Nanoscale Science and Engineering Initiative of the National Science Foundation under NSF Award # EEC-0117770 and the New York State Office of Science, Technology & Academic Research under NYSTAR Contract # C020071

NYSTAR

Cornell University

This page was last updated on September 13, 2005 | Webmaster

MRAM Technology: Status and Future Challenges

Jon Slaughter

Jason Janesky, Renu Dave, Mark DeHerrera
Nick Rizzo, Jijun Sun, Mark Durlam
Johan Åkerman, S. Pietambaram, Ken Smith
Brad Engel, G. Grynkewich, Saied Tehrani

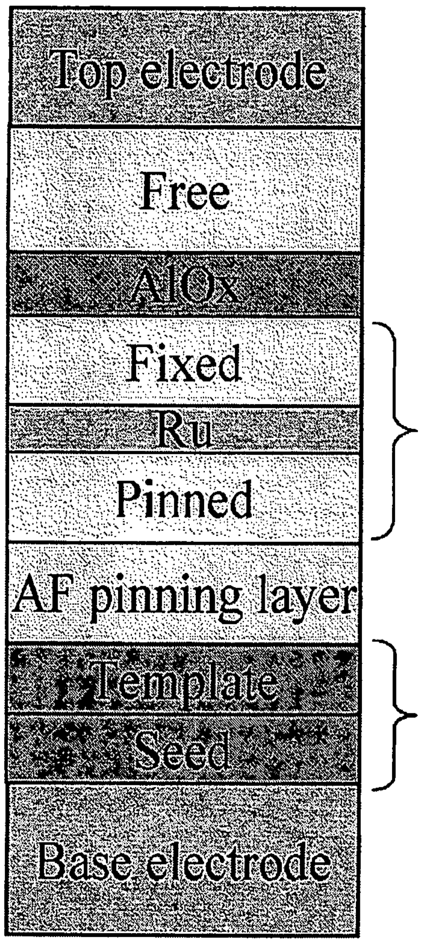
Freescale Semiconductor, a subsidiary of Motorola
Chandler, Arizona

This work was funded in part by DARPA

freescale semiconductor

Full MTJ Stack for MRAM

Full MTJ Stack
for MRAM



- Top electrode: Low resistance contact
- Free: Switches between two magnetic states in applied field. Stores information.
- AlOx: Tunnel barrier. Affects resistance and MR ratio.
- Fixed / Ru / Pinned: Synthetic Antiferromagnet (SAF). AF coupling through Ru layer makes the structure stable in applied magnetic fields. Relative thickness of Fixed and Pinned used to center loop.
- AF pinning layer: Pins the bottom magnetic layers.
- Template / Seed: Seeds growth, determines crystal structure
- Base electrode: Low resistance contact

APPENDIX B

NIMS Now, vol. 2, No. 6, April 2004, pages 1, 3.

from Tsukuba, Japan to the world
NIMS NOW
National Institute for Materials Science
Vol.2 No.6 April, 2004

RESEARCH FRONTIER

In-situ formed two phase metallic glass with surface fractal microstructure

A. A. Kündig, M. Ohnuma, D. H. Ping, T. Ohkubo, K. Hono
Metallic Nanostructure Group
Materials Engineering Laboratory (MEL)

Metallic glasses with better glass forming ability have been sought for many years since its discovery in the 1960's. According to Turnbull, glass formation is favored in alloys with a high reduced glass transition temperature, $T_{rg} = T_g/T_l$, where T_g is the glass transition temperature and T_l is the liquidus temperature. The nucleation of crystals can be suppressed more easily in this condition during quenching due to the combination of a lower driving force for nucleation and a lower mobility in the melt. Indeed, well known good metallic glass formers have compositions which are close to the deep eutectics in multi-component systems that are composed of elements with high negative heats of mixing for all possible combinations. Consequently, the elements mix homogeneously with nearly dense packing configuration in a deep eutectic. Thus, phase separation in a melt is not possible in binary metallic glasses. However, phase separation may be possible in multicomponent metallic glasses, if the values of the negative heats of mixing differ. Several claims have been made on phase separation in bulk metallic glasses. However, since the tendency of phase separation makes the glass unstable, it has been difficult to detect a phase separated microstructure in metallic glasses, although such microstructures have been commonly observed in oxide glasses. < Continued on p.4

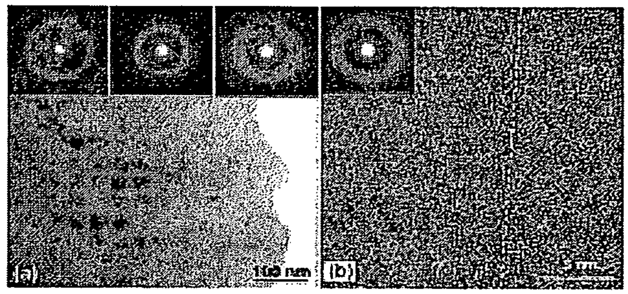


Fig. (b) TEM bright field image and (b) HREM image of a $La_{27.5}Zr_{27.5}Al_{25}Cu_{10}Ni_{10}$ two phase metallic glass. Two types of halo rings corresponding to different average atomic distances are observed in (a). When selected area aperture covers two phase, two halo rings are observed in one selected area electron diffraction pattern. HREM image shows two phases are fully amorphous with only difference in average atomic distance, namely, composition.

NIMS NEWS

Visit by Students from Switzerland's EPFL

On February 24, NIMS received a visit from Prof. Hoffmann and about 20 students from the Swiss Federal Institute of Technology Lausanne (EPFL). The students toured various facilities at the Sengen Site, including the Metallic Nanostructures Group and High Temperature Materials Group in the Materials Engineering Laboratory (MEL) and the Reconstitution Materials Group in the Biomaterials Center (BMC). The visitors viewed the laboratories and experimental equipment with great enthusiasm.

In this issue

State Analysis and Nanotechnology Support

Sei Fukushima
Advanced Beam Analysis Group
Advanced Materials Laboratory (AML)

A main direction in advanced research on analysis technologies is developmental research on physical property analysis methods for the ultramicroscopic region approaching the electron order. One subject of work at the NIMS dedicated beamline (SPring-8 BL15XU) is research based on sound early forecasts of technologies which will become the mainstream, such as the photoelectron microscope introduced in this issue. While we carefully follow these new trends, on the other hand, in an increasing number of cases, we are also keenly aware of the importance of accurately analyzing the average electron state of materials as a whole. The following presents a typical example of this in our general support program for nanotechnology.

Fe_2O_3 and $FeTiO_3$ are each well-known substances. Although both are semi-ferromagnetic insulators, solid solution Fe_2O_3-$FeTiO_3$ is a semiconductor which displays ferrimagnetism and thus has great promise as an environment-friendly material for spintronics. We analyzed the chemical state of this substance, particularly with respect to Ti, in response to a request from a group headed by Asst. Prof. Tatsuo Fujii of Okayama University. While the electronic state of Fe can be analyzed reliably by Mossbauer spectrometry, virtually no practical method is available for Ti, and especially for Ti oxide powders. To solve this problem, at the beamline, we first made high resolution measurements of designated X-rays of Ti with powder samples of TiO_2, TiO_3, and $FeTiO_3$ in order to obtain state standards for Ti (joint work with Asst. Prof. Yoshiaki Ito, Kyoto University, a NIMS guest researcher). As an example, **Fig. 1** shows a high resolution Ti Kα spectrum of $FeTiO_3$. Here, we were surprised to see that Ti in $FeTiO_3$ apparently does not assume the same state (tetravalent) as in TiO_3, but rather, is close to the state (trivalent) in Ti_2O_3. On the other hand, because these oxide specimens were powders, it was nearly impossible to eliminate surface contamination, and analysis by ordinary X-ray photoelectron spectroscopy (XPS) was extremely difficult. This problem was solved with the NIMS dedicated beamline, as the influence of surface contaminants can be effectively eliminated by using a higher excitation energy, making it possible to analyze even insulators in powder form. **Fig. 2** shows the measured results obtained by XPS with high energy excitation and clearly indicates that, in fact, the Ti in $FeTiO_3$ is not in the same state (tetravalent) as in TiO_2. Even though this may be considered common sense, it also demonstrates the importance of reliable confirmation when necessary.

This successful result with $FeTiO_3$ was presented in a 30-minute television program as an example of leading-edge nanotech research.

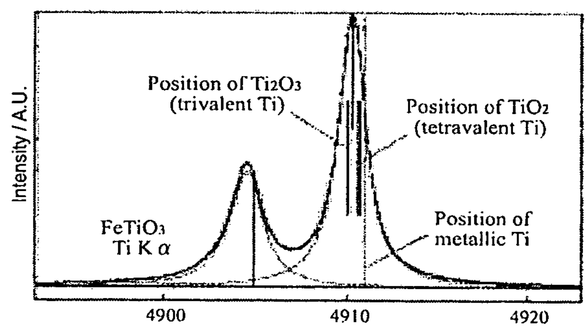


Fig. 1 Example of Ti spectrum obtained by high resolution X-ray spectroscopy.

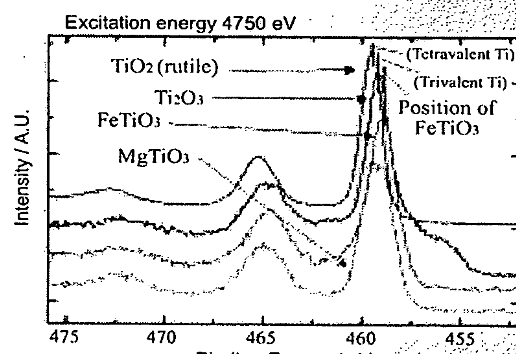


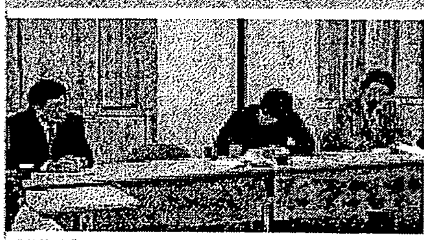
Fig. 2 Example of Ti spectrum by high energy excitation XPS.

For further information, please visit: http://www.nims.go.jp/abg/eng/index.html

JICA Trainee Researchers Visit NIMS

On February 12, five researchers in the JICA program at the National Institute of Advanced Industrial Science and Technology (AIST) visited the NIMS Namiki Site. The young researchers, who came from China, Mongolia, Panama, and Palestine, were given a brief presentation on NIMS, followed by a tour of the laboratories of the Advanced Beam Analysis Group and the High Pressure Group, both in the Advanced Materials Laboratory (AML). At the latter facility, the group saw a demonstration on research in diamond synthesis.

Meeting with the Press to Announce New Developments at Biomaterials Center



On February 13, NIMS held an informal meeting with the press from Tsukuba Science City at the NIMS Namiki Site to announce the progress of a cooperative system between the medical and engineering field and explain future efforts in this area. The new system will be implemented by the Biomaterials Center (BMC). The meeting also featured a lively exchange of opinions with newly-appointed Director Yoshiyuki Uchida of the Medical Applied Technology Group, who is a clinician on service. The Biomaterials Center intends to extend its work into medical applications by developing new biomaterials such as carriers for drug delivery systems (DDS).